

Fiber Enables Battlefield Radio Transmissions

No longer is the radio communicator wedded to antennas.

By Robert K. Ackerman

New fiber optic technology is allowing warfighters to place antennas far away from their radio systems. This capability can both provide greater protection from attack and increase radio signal range.

The technology differs from conventional optical fiber communications in that it does not convert digital signals to photons for transmission down the fiber. Instead, it converts analog radio signals directly into photons. These photons are reconverted into an analog wave signal and amplified at the other end of the fiber.

This allows warfighters to place antennas far away from the radio units they use for communications. When adversaries target the highly visible antennas for attacks, U.S. forces would not be in the vicinity. Similarly, command centers would not be identifiable by telltale antennas on their rooftops.

However, the most useful application might be when radio antennas are placed on mountaintops or on tethered aerostats. This provides greater range and flexibility for line-of-sight radio communications.

Known as Forax and built by Syntonics LLC, Columbia, Maryland, the technology already is in use in several military facilities, including the Pentagon. It is seeing action in Iraq, and U.S. Army engineers are looking at deploying it in Afghanistan where it could solve several challenges facing troops in that rugged country.

Bruce G. Montgomery, founder and president of Syntonics, explains that analog radio frequency (RF) signals cannot be digitized for fiber because the process does not produce the necessary dynamic range. Instead, his company adapted existing analog-over-fiber components to transmit an analog RF signal. The technology can transmit only the RF signal. It cannot transmit power. So, an amplifier at the end of the fiber boosts the low-level signal to a strength suitable for transmission.



Technicians launch an aerostat containing a High Antennas for Radio Communications, or HARC, payload. An optical fiber tether carries an analog ground radio signal to its corresponding antenna aboard the aerostat, providing greatly increased transmission range.

Traditional radios are attached directly or are tethered to an antenna by a coaxial cable. But the fiber technology allows the antenna to be placed up to tens of kilometers away from the radio. The only limits on distance are the RF signal range, Montgomery notes. If that radio has a range of 200 kilometers, a 50-kilometer distance between the radio and the antenna would leave the radio with a 150-kilometer range. Nonetheless, an antenna could be placed more than 100 kilometers away from a radio if the fiber is equipped with optical amplifiers—standard erbium-doped fiber amplifiers would work well.

Fiber links also provide an added measure of security. “We’re transporting a black signal over what is fundamentally a highly secure media,” Montgomery points out. “It is possible to eavesdrop on fiber, but it’s hard.”

Accordingly, a radio linked by fiber to its antenna now can be placed inside of a sensitive compartmented information facility (SCIF). Where SCIF standards prohibit running a coaxial cable through a SCIF wall, an optical fiber can be

installed through that wall—as many are. A radio can be placed in a SCIF for direct operation by people in that facility, and its RF signal can be sent via existing optical fiber to an antenna located far away from the SCIF.

Having those antennas in a distant location also avoids the common image of a command center being easily identifiable by the cluster of antennas on its roof. An unobtrusive building might offer no visible clue as to its importance. Similarly, two separate sets of antennas serving a command center could be located far apart, which would increase network survivability in the event one is destroyed.

Montgomery relates that Forax first appeared in 2005 when his company sold a version to the Pentagon during the building's renovation project. One unit was placed in the Chairman of the Joint Chiefs of Staff communications suite, while another was located in an Army command post in the building's sub-basement.

He notes that prior to the September 11, 2001, terrorist attack, most Pentagon radio rooms were on the building's top floors, where they could be located directly under their systems' communications antennas. Their connecting coaxial cables could be no longer than about 200 feet. Now, those radios can be placed anywhere in the building. Antenna connectivity can be attained simply by patching into any of the fibers that make up the Pentagon's extensive communications infrastructure.

The U.S. Air Force is using Forax technology in Europe in areas where it would be impossible to place an antenna. Staff Sgt. Keith G. Morris, USAF, with the 603rd Air Communications Squadron (ACOMS)/SCO at Ramstein Air Base, Germany, explains that the system also provides secure communication capability to areas where RF would violate the emissions security standards. Its plug-and-play nature minimizes upkeep and downtime. He notes that it is compliant with demand assigned multiple access (DAMA) standards for data transmissions, and it also works perfectly with the Harris high-performance waveform.

Adapting a Forax unit to a radio entails learning how the radio performs. Montgomery notes that many military radio manufacturers are somewhat closemouthed about how their radios function. A Forax system must be engineered to operate seamlessly with its host radio, and this often requires parsing the radio's capabilities.

One of the foremost applications for Forax technology is an effort known as High Antennas for Radio Communications, or HARC. Up to six RF antennas can be placed on a tethered aerostat that connects to ground radios via a single optical fiber link. This system can float high above an area where line-of-sight communications are hindered by mountainous terrain or urban canyons.

The Army is operating many aerostats for mostly intelligence, surveillance and reconnaissance missions, Montgomery points out. These aerostats can be used as radio towers if the equipment placed on them is not too large or too heavy. With HARC, the bulky parent radios are based on the ground in the tactical operations center while the lighter antennas are about 2,000 feet above ground onboard the aerostat.

One challenge was to engineer a lightweight aerial payload comprising the Forax circuitry box and an antenna system that could fit aboard the Persistent

Threat Detection System (PTDS) aerostats that are floating above Iraq. These PTDS aerostats could accommodate some extra weight and power consumption, Montgomery relates. The HARC Forax configuration supports the Single Channel Ground and Airborne Radio System (SINCGARS), the Enhanced Position Location Reporting System (EPLRS), the Land Mobile Radio (LMR), cellular systems and the Joint Tactical Radio System (JTRS) including Ground Mobile Radio (GMR).

This configuration provides two-way signals from six radios, along with a gigabit radio stream, over a single optical fiber. The radios, which span the range from traditional push-to-talk units to modern software-defined systems, can be mixed among the many different types that HARC accommodates. "We're combining and uncombining signals in both the RF and the optical domains to do that," Montgomery notes.

The HARC aerostat can serve as an EPLRS network coordination node. EPLRS is serving a vital role as a blue force tracking system. With a single EPLRS antenna consistently in sight high

above the ground-based EPLRS units, all of the EPLRS radios remain synchronized with the network because none of them will fall out of the network and need to reacquire it. The same will be true of JTRS radios, Montgomery states.

A system sent to Iraq by the Army's Communications-Electronics Research, Development and Engineering Center (CERDEC) already is paying dividends. Ron Testa, lead project engineer, tactical satellite and airborne communications branch, Space and Terrestrial Communications Directorate, CERDEC, reports that HARC is extending radio communications ranges by as much as 100 kilometers. The system is working as hoped, and feedback from its limited use in Iraq has been positive, he says.

Frank Van Syckle, branch chief, product manager network system integration (NSI) support branch, Space and Terrestrial Communications Directorate, CERDEC, is a former science technology adviser at the U.S. Central Command (CENTCOM). He explains that the requirements from Iraq focused on support for logistics, convoy support and urban patrols.



A radio antenna aboard a HARC aerostat is connected to a radio interface unit on the ground. Forax technology allows the radio's analog signal to be carried via fiber without digitization.

Being able to use HARC for EPLRS has provided increased blue force location information, he relates. And, the training cycle for HARC/Forax is fairly short.

In Afghanistan, U.S. forces are flying a single SINC-GARS radio unit conventionally over the battlefield. However, HARC will allow multiple networks to operate from the air aboard aerostats. CENTCOM is seeking authorization to use HARC in Afghanistan, explains Dr. James Sommer, Army science adviser at CENTCOM.

The lone aerostat floating over Afghanistan is deemed vital to PTDS operations, so engineers looking to hook up a Forax system are forced to wait for it to be returned to Earth for maintenance. With that maintenance, Forax will be installed on the Afghanistan aerostat. Its use will depend on permission from J-6 frequency managers, Sommer notes. This permission is required to avoid interference problems from quick reaction capability equipment appearing suddenly in theater.

While the aerostat's primary PTDS mission is intelligence-oriented, having a HARC capability can aid that, Sommer points out. "Your disadvantaged warfighter may have the best intelligence in the world, but if he can't communicate it back to those who need it, what does it matter? Communications are important to [intelligence personnel's] work." In Iraq, an EPLRS-equipped HARC aerostat proved to be an effective data transfer system, especially for biometric data transmitted directly by individual soldiers.

He states that the CENTCOM J-6 has endorsed placing HARC on all the PTDS aerostats as part of layer one of the command's aerial layer working group. CENTCOM likes the HARC capability and is working to put it into theater, he declares.

Sommer allows that HARC does not solve every RF communications challenge in Afghanistan. For example, some of that country's mountain ranges rise higher than the upper deployment altitude of a HARC PTDS. Nonetheless, HARC aerostats could some day compose a mesh network, he suggests.

Syntonics' Montgomery sees a wide future for airborne Forax applications. "Programmatically, I think that the aerostat application may turn out to be the killer app for RF over fiber," he suggests. "Once people begin to use this wide-area networking capability—you pop up a balloon, and all of a sudden everyone in the county or in the state is talking on that network—that sort of capability will be useful not only to the military strategically in Afghanistan, but also to the military tactically. You could have a fairly low-echelon unit deploy a pop-up balloon 500 feet up from a towed trailer, and suddenly they're talking over the entire county." Montgomery allows that his company is in discussions with a

foreign military to develop this type of capability for them.

Other potential users include first responders amid a disaster scene where a communications infrastructure has been rendered inoperative. A balloon could carry a cell phone antenna tethered to a vehicle-based portable base station. The responding team even could carry several hundred cell phones keyed to the Forax balloon cell system for rescue workers.

For the future, Syntonics aims to improve Forax by developing higher-performance links. Under the Small Business Innovative Research (SBIR) effort, the U.S. Navy is funding the development of advanced RF over fiber links with higher technical performance limits. The goal is to incorporate this technology aboard ships, Montgomery explains. Large ships in particular run into difficulties with long distances between radios and antennas, which can force the Navy to place antennas in inconvenient areas of the ship. A high-performance RF-over-fiber system would leave a small footprint and allow greater flexibility in antenna location aboard a ship. The company hopes to produce a commercial product within a year, Montgomery offers.

CENTCOM's Sommer reports that the Naval Air Systems Command is looking at using Forax technology onboard the new Persistent Ground Surveillance System (PGSS). This would effectively create a lightweight version of the HARC system.

Van Syckle allows that it is difficult for engineers to obtain quantitative performance data from the single HARC unit deployed in Iraq. Testa reports that the Army Test and Evaluation Command is evaluating HARC performance with the aim of amassing quantitative data that would support future program decisions. When that test report is ready, its results will be reported to units that need a HARC capability.

The HARC effort is a quick reaction capability, which means it is not a program of record with any formal program management. The Defense Department Rapid Reaction Technology Office, the Army's Rapid Equipping Force and the Chairman, Joint Staff, Combatant Commander Initiative joined to fund the HARC effort, Van Syckle says. If the Army selects it as an enduring capability, then it will become a budget item with a formal sustainment process.

WEB RESOURCES

Syntonics Forax: www.syntonicscorp.com/products/products-foraxRF.html

U.S. Central Command: www.centcom.mil

U.S. Army CERDEC: www.cerdec.army.mil



Sales@SyntonicsCorp.com

www.SyntonicsCorp.com

+1.410.884.0500 x203

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